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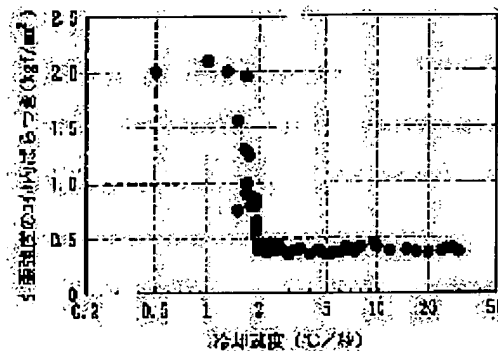
(72)Inventor : IDOJIRI HIROSHI
KANESADA YASUYUKI
HASEGAWA TOYOFUMI

(54) PRODUCTION OF HIGH STRENGTH NON-HEAT TREATED STEEL WIRE FOR BOLT, EXCELLENT IN COLD HEADING PROPERTY

(57)Abstract:

PROBLEM TO BE SOLVED: To newly produce a steel wire capable of sufficiently satisfying cold heading property at the time of bolt forming, even if composed of a non-heat treated steel prepared by omitting spheroidizing annealing and further omitting the last quench-and-temper treatment.

SOLUTION: A steel stock, having a composition containing 0.15-0.35% C, ≤0.05% Si, 0.70-1.50% Mn, ≤0.005% N, and ≤0.20% Cr, is used and cooled, after hot rolling, at a rate of ≥2°C/sec, and the resultant wire rod is wiredrawn at 20-35% reduction of area, by which the steel wire having (700 to 930)N/mm² tensile strength is obtained. By this method, the production cost at the time of bolt forming can be reduced.



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CLAIMS

[Claim(s)]

[Claim 1] C : 0.15 to 0.35 mass % (mass % only writes it as % below)

Si: Less than [0.05%] (0% is included)

Mn: 0.70 - 1.50%N : 0.005% or less (0% is included)

Cr: Less than [0.20%] (0% is included)

It is 2 the tensile strength of 700-930Ns/mm by giving the wire rod obtained by performing cooling after hot rolling at 2 degrees C/second or more in rate to wire drawing by 20 - 35% of reduction of area using the steel materials to satisfy. The manufacture approach of the steel wire for non-temper bolts excellent in the heading nature characterized by obtaining steel wire.

[Claim 2] The steel materials according to claim 1 which made C content 0.15 - 0.25%, and were carried out to making Cr contain 0.01 to 0.20% as occasion demands are used, and it is 2 the tensile strength of 700-820Ns/mm. The manufacture approach of the steel wire for non-temper bolts indicated by claim 1 which obtains steel wire.

[Claim 3] The steel materials according to claim 1 which made C content 0.25 to 0.35%, and made Cr content 0.03 - 0.20% are used, and it is 2 the tensile strength of 800-930Ns/mm. The manufacture approach of the steel wire for non-temper bolts indicated by claim 1 which obtains steel wire.

[Claim 4] The manufacture approach of the steel wire for non-temper bolts indicated in advance of wire drawing by either of claims 1-3 which anneal at 550-650 degrees C.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] For this invention, even if it omits a balling-up annealing process, a steel with the deformation resistance low enough at the time of bolt shaping is also 2 700-930Ns/mm. It is related with the manufacture approach of the steel wire for non-temper bolts of demonstrating the high intensity level to say.

[0002]

[Description of the Prior Art] Tensile strength 700-930N/mm² Although a class bolt is manufactured using the wire rod and steel bar which consist of medium carbon steel or low alloy steel, in the process usual in that case, through balling-up annealing processing, cold drawing processing, bolt shaping between the colds, and thread rolling, finally it performs hardening and tempering processing and is adjusting them to the desired property.

[0003] On the other hand, as an inclination in recent years, the demand of energy saving or a production cost cut became strong, the abbreviation of balling-up annealing or hardening / tempering processing was planned, and the orientation to the so-called non-temper bolt has become strong.

[0004] With such a non-temper bolt, since it was required to attain the predetermined tensile strength demanded as a bolt in the phase of the steel wire before bolt shaping, in tensile strength, a high thing will be used rather than the balling-up annealing material in an old temper bolt manufacture process, therefore the common fault that the cold headability at the time of bolt shaping was bad was pointed out.

[0005] By JP,60-406,B, reducing deformation resistance by performing wire drawing before bolt shaping (a kind of Bauschinger effect being used) is proposed, and by JP,54-20931,B, while reducing C, raising a cold headability is proposed by adding precipitation-strengthening mold elements, such as Nb and V, there. However, also by these approaches, compared with the conventional balling-up annealing material, an improvement of a cold headability is inadequate, the tool life at the time of bolt shaping is short, and much more improvement is desired.

[0006] On the other hand by JP,5-30884,B, not stopping at addition of mere wire drawing, but carrying out from a viewpoint of pulling out above-mentioned Bauschinger effect to the maximum extent, combining synthetically the controlled cooling after chemical entity adjustment of steel, organization control, and rolling etc. is proposed. Although this approach demonstrates suitable effectiveness, since it is seen on the whole and needs complicated control, it is hard to say that it is not necessarily rich in versatility.

[0007]

[Problem(s) to be Solved by the Invention] This invention is made in consideration of the above situations, and even if it is non-heat-treated steel which omits balling-up annealing and omits the last hardening / tempering processing further, it is made for the purpose of development of the new technique in which the cold headability at the time of bolt shaping can fully be reduced. That is, it is going to establish the manufacture approach that the steel wire for non-temper bolts with the deformation resistance low enough at the time of bolt shaping of the purpose of this invention is new, and simple.

[0008]

[Means for Solving the Problem] This invention which was able to attain the above-mentioned technical

problem is C. : Less than [0.15-0.35%Si:0.05%] (0% is included)

Mn: 0.70 - 1.50%N : 0.005% or less (0% is included)

Cr: Less than [0.20%] (0% is included)

It is 2 the tensile strength of 700-930Ns/mm by giving the wire rod obtained by performing cooling after hot rolling at 2 degrees C/second or more in rate to wire drawing by 20 - 35% of reduction of area using the steel materials to satisfy. Let it be a summary to obtain steel wire.

[0009] In addition, the steel wire for high intensity non-temper bolts manufactured by this invention is classifiable into the following two groups with the tensile strength level.

(A) Tensile strength 700-820N/mm² (Steel-wire B) tensile strength 800-930N/mm² Steel wire [0010] A cold headability falls as tensile strength generally increases. Therefore, it sets to this invention and is tensile strength 700-930Ns/mm widely 2 When it planned, it expressed with the above extensive conventions so that both the field (A) where tensile strength is comparatively low, and a comparatively high field (B) might be satisfied, but when classifying into (A) and (B) and planning the tensile strength of the respectively narrow specific numeric-value range, it is desirable to control a chemical entity as follows.

[0011] (A) It is C when planning a group's steel wire. : 0.15 - 0.25% (notes: a little lessen C)

Si: Less than [0.05%] (0% is included)

Mn: 0.70 - 1.50%N : 0.005% or less (0% is included)

It is satisfied and also the steel materials which made Cr:0.01-0.20% contain are used as occasion demands.

[0012] (B) It is C when planning a group's steel wire. : 0.25 - 0.35% (notes: make [many / a little] C)

Si: Less than [0.05%] (0% is included)

Mn: 0.70 - 1.50%N : 0.005% or less (0% is included)

Cr: Use the steel materials with which are satisfied of 0.03-0.20%.

[0013] Although the steel wire for high intensity non-temper bolts manufactured by this invention can naturally be given to bolt shaping between the colds as it is, when you wish, it does not eliminate annealing at 550-650 degrees C in advance of wire drawing.

[0014]

[Embodiment of the Invention] This invention which consists of the above-mentioned configuration is specified from three elements called the reduction of area in the chemical entity of steel, the cooling rate after hot working, and wire drawing, and this invention is carried out with various gestalten with combination with each [these] suitable element. Therefore, these elements are explained below, respectively.

[0015] What expects actively an operation of solid-solution-strengthening mold elements, such as C, Mn, and Si, and the thing which added precipitation-strengthening mold elements, such as V, Nb, and Ti, to them, and attained much more high intensity-ization are known by the steel-wire material for non-temper bolts known conventionally [of steel / chemical entity]. While high intensity was attained compared with the thing of only a solid-solution-strengthening mold element, some which added a precipitation-strengthening mold element like the latter among these had the inclination for deformation resistance to become large, when the same reinforcement compared. The carbon nitride which deposited checks a cold headability and this is considered because extent of the inhibition is larger than that of a solid-solution-strengthening mold element.

[0016] Moreover, even if it was similarly solid-solution-strengthening mold elements, it was shown clearly by this invention person's etc. research that Si brought about the rise of about 1.5 times as many deformation resistance as this to the rise effectiveness of the same reinforcement compared with C and Mn (refer to drawing 1). Although drawing 1 plots tensile strength and each amount of rises of deformation resistance about each steel materials which the content of C, Si, and Mn was changed and were obtained, if the effect to the rise (axis of ordinate) of the deformation resistance (axis of abscissa) when carrying out the same amount rise of the tensile strength by addition of each element like distinct from this drawing is seen, Si shows the value with about 1.5 times higher C and Mn ratio **** deformation resistance augend.

[0017] Then, the conclusion that what was used as much as possible only as the solid-solution-strengthening mold element is desirable as for the component system which can make deformation resistance in the same reinforcement small as much as possible as a result of considering these synthetically, and it was useful making the lack of on the strength by having lessened Si as much as possible and having lessened Si also in the solid-solution-strengthening mold element into extent compensated by C, Mn, or addition of a precipitation-strengthening mold element moreover was reached. In this way, it is as follows when the convention range and its reason for a setup of the defined this invention chemical entity are explained.

When planning the steel wire (steel wire of tensile-strength 700-820N/mm²) of C:0.15 - 0.35%, however the (A) group and 0.25% [:0.15 -] (B) group's steel wire (steel wire of tensile-strength 800-930N/mm²) is planned: 0.25 - 0.35% [0018] Although C serves as a subject of the strengthening element in this invention steel, the reduction of area in the wire drawing after hot rolling was defined as mentioned above corresponding to target tensile strength, respectively under the premise of making it the convention range (20 - 35%) of this invention. If there are too few amounts of C, required reinforcement will not be obtained, but if many [too], it will be easy to cause increase of deformation resistance. In addition, since it becomes very difficult to avoid increase of deformation resistance inevitably to obtain a high strength steel wire rather than it belongs to the (B) group, it is more desirable to hold down a upper limit to about 0.30%. However, since we were anxious about the fall on the strength by this annealing as a deformation mode of this invention when 550-650-degree C low temperature annealing was carried out before wire drawing, it determined approving to the 0.35% of the above-mentioned upper limits as this invention range.

[0019] Si: Less than [0.05%] (0% is included)

Since Si is an element which is easy to increase deformation resistance like the above-mentioned, to lessen as much as possible is desired. However, if the actual condition of industrial production is taken into consideration, it is appropriate from the financial side to consider about 0.05% to be an upper limit.

[0020] Mn: 0.70 to 1.50%, Mn is a solid-solution-strengthening element and replaces the solid-solution-strengthening operation by C with this invention. Since superfluous addition causes increase of deformation resistance also in Mn, don't make it add exceeding 1.50%, although at least 0.70% of addition is made indispensable in this invention from the main point of having set C as the fewer range and supplementing with this since increase of the deformation resistance by superfluous addition of C is avoided.

[0021] N:0.005% or less (0% is included)

Although it combined with V, below-mentioned Nb, and below-mentioned Ti and the precipitation-strengthening operation was demonstrated when N existed, the above-mentioned upper limit was defined here from a viewpoint of controlling the strain aging accompanying the temperature rise at the time of bolt heading.

[0022] Cr: Less than [0.20%] (0% is included)

However, when the (A) group's steel wire (steel wire of tensile-strength 700-820N/mm²) is planned: Cr makes the addition in the case of positioning [the element which may be added if needed, and] and adding 0.01 - 0.20%.

(B) When a group's steel wire (steel wire of tensile strength 800-930N/mm²) is planned : add Cr 0.03 to 0.20% in indispensable.

Although Cr is an element contributed to the improvement in on the strength, cautions are taken for the addition thought to change like **** according to target tensile strength. Anyway, since the deformation resistance at the time of bolt heading increased when it added exceeding 0.20%, 0.20% was determined as the upper limit. If it adds exceeding 0.20% when planning the (B) group's steel wire especially, since tensile strength is high and it will become easy to produce a toughness fall, a upper limit has more important semantics.

[0023] Although the limit according to rank is not prepared about other elements as long as the object steel of this invention satisfies the above-mentioned chemical entity, the element like the following may be added by the need. And most generally everything but the above-mentioned chemical entity consists of Fe.

and an unescapable impurity substantially.

[0024] V : 0.3% or less (0% is not included)

Nb: Less than [0.1%] (0% is not included)

Ti: Less than [0.06%] (0% is not included)

These combine with carbon and nitrogen which exist in steel, and demonstrate an operation common as a precipitation-strengthening mold element. Since the above-mentioned operation effectiveness will be acquired if any one or more sorts exist among these, these are positioned as an alloying element [alternative / request-]. Moreover, since these operations are demonstrated also in existence of ultralow volume, they do not need to set up a lower limit. About the another side upper limit, the operation effectiveness by those addition determined it as less than [Nb:0.1%] and less than [Ti:0.06%] V:0.3% or less from a viewpoint of the value which reaches saturation.

[0025] The cooling rate after hot rolling: In the general manufacture process of a non-temper bolt, the variation in the reinforcement which it produced in the hot rolling phase that the heat treatment process for canceling the variation in strong is incorporated for the reason appears as variation in a product as it is. Then, in this invention, examination was performed from a viewpoint that it is required to suppress the variation in strong to the usual permissible level in a wire rod phase (preceding paragraph story of bolt processing). Consequently, as shown in drawing 2, when the cooling rate after hot rolling became quick, and especially when [whose strong variation falls at a stretch] it was made to cool more quickly 2 degrees C /than a second, it turned out that the variation in strong stabilizes and decreases. in addition, in consideration of various factors influence the variation in strong in complex and multiplication, the range of the variation usually permit be 2 15 kgf(s)/mm in a final product phase. when think including be the following, it resulted in the conclusion that it be good to set up preferably 2 degrees C /or more of cooling rates after hot rolling (cooling rate in the all points of a coil) in 3 degrees C/[a second and] or more a second in this invention.

[0026] Work hardening by the reduction-of-area wire drawing at the time of wire drawing increases the deformation resistance at the time of bolt heading. If wire drawing is generally performed, it is known that the deformation resistance at the time of bolt heading will decrease. However, it is not clarified until now about a rate of wire drawing as for which deformation resistance is made to min. this invention person etc. had the lowest deformation resistance, when the reduction of area was among 20 - 35% as shown in drawing 3 as a result of inquiring from this viewpoint, and in a field with less reduction of area than 20%, and more fields than 35%, it turned out that each has invited increase of deformation resistance. From such a place, the reduction of area was determined as for 20 - 35% in this invention.

[0027] Although the manufacture process of low-temperature-annealing this invention before wire drawing is essentially constituted like the above, even if it is the case where bolt shaping is performed under higher working ratio, it is effective to give low temperature annealing of 550-650-degree-C level in advance of wire drawing from the main point of improving ductility, such as a diaphragm value, to prevent a processing crack. It is based on the viewpoint of maintenance of tensile strength that having determined it as 550 degrees C or more determined it as 650 degrees C or less based on the viewpoint of toughness reservation.

[0028]

[Example]

The test specimen chemical entity in the case of planning the (A) group's steel wire (steel wire of tensile strength 700-820N/mm²) was shown in the chemical entity table 1 of a test specimen, and the test specimen chemical entity in the case of planning the (B) group's steel wire (steel wire of tensile strength 800-930N/mm²) was shown in Table 2.

[0029]

[Table 1]

区分	番号	C	Si	Mn	P	S	Cr	N
実 施 例	1	0.20	0.02	1.45	0.010	0.009	0.03	0.0030
	2	0.22	0.03	1.45	0.009	0.007	0.03	0.0027
	3	0.22	0.01	1.47	0.011	0.010	0.03	0.0029
	4	0.23	0.04	1.40	0.010	0.007	0.03	0.0027
	5	0.24	0.05	1.21	0.010	0.009	0.03	0.0025
	6	0.25	0.02	1.10	0.009	0.007	0.03	0.0030
	7	0.25	0.04	1.45	0.011	0.010	0.04	0.0028
	8	0.24	0.03	1.49	0.010	0.009	0.03	0.0027
比 較 例	9	0.30	0.01	1.40	0.010	0.007	0.03	0.0029
	10	0.13	0.03	1.45	0.011	0.008	0.02	0.0028
	11	0.25	0.20	1.46	0.012	0.010	0.03	0.0030
	12	0.25	0.05	2.00	0.009	0.007	0.04	0.0027
	13	0.22	0.03	0.55	0.010	0.007	0.04	0.0028
	14	0.23	0.04	1.40	0.010	0.011	0.03	0.0060
	15	0.24	0.05	1.21	0.009	0.008	0.02	0.0027
	16	0.24	0.04	1.40	0.011	0.009	0.03	0.0030
	17	0.25	0.03	1.24	0.011	0.010	0.02	0.0028
	18	0.25	0.02	1.44	0.009	0.008	0.04	0.0029
	19	0.44	0.21	0.95	0.011	0.011	0.03	0.0053

(質量%)

[0030]

[Table 2]

区分	番号	C	Si	Mn	P	S	Cr	N
実 施 例	20	0.27	0.02	1.40	0.011	0.010	0.16	0.0029
	21	0.29	0.03	1.10	0.009	0.008	0.15	0.0027
	22	0.27	0.02	1.45	0.010	0.009	0.15	0.0028
	23	0.28	0.03	1.43	0.010	0.007	0.10	0.0027
	24	0.29	0.04	1.30	0.009	0.009	0.08	0.0026
	25	0.34	0.03	1.49	0.009	0.007	0.05	0.0030
	26	0.33	0.05	1.50	0.010	0.008	0.04	0.0029
	27	0.34	0.05	1.47	0.010	0.009	0.05	0.0027
比 較 例	28	0.40	0.04	0.72	0.009	0.007	0.06	0.0030
	29	0.22	0.04	1.45	0.010	0.008	0.13	0.0029
	30	0.27	0.25	1.15	0.012	0.010	0.10	0.0030
	31	0.30	0.02	2.10	0.010	0.007	0.10	0.0025
	32	0.33	0.04	0.65	0.009	0.008	0.10	0.0027
	33	0.32	0.03	1.49	0.010	0.009	0.25	0.0030
	34	0.27	0.03	1.25	0.009	0.009	0.15	0.0057
	35	0.29	0.02	1.15	0.012	0.008	0.10	0.0032
	36	0.28	0.04	1.40	0.010	0.007	0.11	0.0031
	37	0.27	0.03	1.45	0.011	0.011	0.15	0.0030
	38	0.28	0.02	1.44	0.010	0.008	0.11	0.0027
	39	0.45	0.27	1.10	0.011	0.009	0.03	0.0050

(質量%)

[0031] After ingoting the steel which consists of a chemical entity of steel-wire manufacture and the bolt shaping tables 1 and 2, the reinforcing bars of 10mmphi were manufactured with hot rolling, in order to obtain the size of choice, and reinforcement after that, wire drawing was performed, and bolt shaping was performed. About the sample offering steel of Table 1, wire drawing and bolt shaping were performed on condition that Table 3, and wire drawing and bolt shaping were performed on condition that Table 4 about the sample offering steel of Table 2.

[0032]

[Table 3]

区分	番号	圧延条件		圧延材の諸性質		焼なまし条件		伸線加工率 (%)	伸線材の機械的性質		引張強度のコイル内バラツキ σ (kgf/mm ²)	変形抵抗 (kgf/mm ²)	ボルト成形時の工具寿命
		冷却速度 (℃/秒)		引張強さ (N/mm ²)	絞り (%)	温度 (℃)	冷却		引張強さ (N/mm ²)	絞り (%)			
実施	1	4		545	71.8	無し		30	735	64.0	0.39	74.0	○
	2	4		569	70.7			30	761	62.9	0.38	76.3	○
	3	4		566	70.9			30	758	63.1	0.37	75.9	○
	4	4		577	70.3			27	752	63.2	0.39	78.5	○
	5	3		573	70.5			25	737	64.0	0.40	78.0	○
例	6	5		565	71.0	600	AC #1	30	702	67.5	0.35	76.3	○
	7	4		603	69.0	600	AC #1	30	741	66.5	0.37	78.5	○
	8	4		594	69.5	570	AC #1	25	705	68.0	0.39	78.8	○
比較例	9	5		644	67.3	無し		30	845	59.5	0.39	84.3	×
	10	5		490	75.0			30	670	69.5	0.40	66.9	○
	11	5		630	68.5			30	830	60.9	0.42	83.0	×
	12	5		658	66.3			30	850	58.5	0.40	89.5	×
	13	5		484	74.8			30	682	67.0	0.38	76.2	○
	14	5		585	67.0			30	755	61.0	0.55	84.5	×
	15	1		565	72.5			25	727	65.7	1.95	79.5	△
	16	4		588	69.8			15	687	67.6	0.39	83.5	×
	17	4		561	70.2			40	841	60.2	0.40	90.4	×
	18	4		601	68.5	510	AC #1	30	750	60.5	0.50	76.5	△
	19	4		735	50.5	球状化焼鈍 #2		15	637	57.0	0.45	88.0	×

*1: AC-空冷

○: 良好、△: やや悪い、×: 悪い

*2: 球状化焼鈍後伸線

[0033]

[Table 4]

区分	番号	圧延条件		圧延材の諸性質		焼なまし条件		伸線材の機械的性質		引張強度のコイル内バラツキ σ (kgf/mm ²)	変形抵抗 (kgf/mm ²)	ボルト成形時の工具寿命
		冷却速度 (℃/秒)	引張強さ (N/mm ²)	絞り (%)	温度 (℃)	冷却	伸線 加工率 (%)	引張強さ (N/mm ²)	絞り (%)			
実施例	20	3	652	67.6	無し		30	839	62.0	0.38	84.5	○
	21	4	645	67.8			30	832	61.9	0.39	86.6	○
	22	3	655	67.4			30	841	61.1	0.39	84.3	○
	23	3	654	66.8			30	842	60.2	0.40	84.6	○
	24	4	650	66.7			27	818	61.0	0.41	86.4	○
	25	4	714	64.0	600	AC #1	30	810	64.2	0.36	83.8	○
	26	4	705	65.5	600	AC #1	30	836	65.1	0.35	82.4	○
	27	4	715	63.8	560	AC #1	30	818	63.5	0.34	84.3	○
	28	4	708	64.0	無し		25	863	58.4	0.43	98.2	×
	29	4	602	66.5			30	788	62.7	0.44	79.1	○
比較例	30	4	671	65.0			30	858	59.2	0.41	90.9	×
	31	4	736	62.9			30	923	56.1	0.51	92.5	×
	32	4	636	67.7			30	795	63.9	0.42	81.5	○
	33	4	738	65.5			30	924	55.5	0.60	96.0	×
	34	3	638	68.1			30	825	61.7	0.50	90.5	×
	35	1	636	67.7			30	822	63.2	2.05	88.4	×
	36	4	656	66.8			15	749	65.6	0.48	89.8	×
	37	4	657	67.2			40	884	58.4	0.45	91.4	×
	38	4	655	66.9	510	AC #1	30	770	59.4	0.47	80.1	○
	39	4	735	50.5	球状化焼鈍 #2		15	637	57.0	0.45	88.0	×

*1: AC-空冷

○: 良好、△: やや悪い、×: 悪い

*2: 球状化焼鈍後伸線

[0034] It is the conditions which indicated to Table 3 about the former, and were indicated to Table 4 about the latter, respectively, and low temperature annealing was given about sample offering steel No.6 of Table 1, 7, 8 and 18 and sample offering steel No.25 of Table 2, and 26, 27 and 38 before wire drawing. Moreover, about sample offering steel No.19 of Table 1, and sample offering steel No.39 of Table 2, conventionally, according to the process, it is the conditions which indicated to Table 3 about the former, and were indicated to Table 4 about the latter, respectively, and spheroidizing was given before wire drawing.

[0035] In this way, using the obtained wire drawing material, it set between the colds, the test piece for lump processing (height / diameter ratio = 1.5) was produced, and the deformation resistance at the time of compression processing was measured using the confining pressure board which attached the dice with a concentric circle-like slot. The average rate of strain at this time is 2S-1. In addition, it is known that deformation resistance has a heading tool life at the time of actual bolt processing and correlation. moreover, a load in case the average strain of count of deformation resistance is 1.69 (75% of rolling reduction) -- a restraint factor and the initial cross section before deformation -- **** -- it asked by things.

[0036] Tables 1 and 3 which plan the steel wire (steel wire of tensile strength 700-820N/mm²) of the consideration **** (A) group of a test result are considered. As for example No.1-8 which satisfy the conditions of this invention, the tensile strength of wire drawing material is contained in target within the limits. that No.9-13, and 16 and 17, (on the other hand, have the tensile strength of wire drawing material smaller than desired value among the examples of a comparison **** -- bolt reinforcement is insufficient) -- it was too large (deformation resistance is excessive), and has separated from the target range. On the other hand, example No.1-8 have low deformation resistance compared with example No. of comparison 9, 11, 12 and 14 (these have more C, Si, Mn, or N than this invention convention range), and example No. of comparison 19 (spheroidizing is performed after hot rolling), and its tool life at the time of bolt shaping is good. As for the tool life at the time of bolt shaping, some is [example No. of comparison 15] bad while the tensile strength of wire drawing material shows large variation in a coil, since the cooling rate after hot rolling is slow. Furthermore, when the effect of the reduction of area at the time of wire drawing is considered, since the reduction of area is small, and example No. of comparison 17 have the large reduction of area, all have large deformation resistance and the tool life at the time of bolt shaping is bad [example

No.of comparison 16].

[0037] In addition, although example No.6-8 and example No.of comparison 18 compare the effect of this annealing temperature at the time of performing annealing processing before wire drawing, compared with the former, the drawing value of wire drawing material is low a little, and also the latter has given the good result in the evaluation criteria of deformation resistance and others.

[0038] Next, Tables 2 and 4 which plan the (B) group's steel wire (steel wire of tensile strength 800-930N/mm²) are considered. Although, as for example No.20-27 which satisfy the conditions of this invention, the tensile strength of wire drawing material is contained in target within the limits, among the examples of a comparison, No.29, and 32, 36 and 38 have the tensile strength of wire drawing material smaller than desired value, and they run short of bolt reinforcement. On the other hand, example No.20-27 have low deformation resistance compared with example No.of comparison 28, 30, 31, 33 and 34 (these have more C, Si, Mn, N, or Cr than this invention convention range), and example No.of comparison 39 (spheroidizing is performed after hot rolling), and its tool life at the time of bolt shaping is good. As for the tool life at the time of bolt shaping, some is [example No.of comparison 35] bad while the tensile strength of wire drawing material shows large variation in a coil, since the cooling rate after hot rolling is slow. Furthermore, when it sees about the effect of the reduction of area at the time of wire drawing, since the reduction of area is small, and example No.of comparison 37 have the large reduction of area, all have large deformation resistance and the tool life at the time of bolt shaping is bad [example No.of comparison 36].

[0039] In addition, although example No.25-27 and example No.of comparison 38 compare the effect of this annealing temperature at the time of performing annealing processing before wire drawing, compared with the former, the drawing value of wire drawing material is low a little, and also the latter has given the good result in the evaluation criteria of deformation resistance and others.

[0040]

[Effect of the Invention] Satisfying the need reinforcement as a non-temper bolt, since this invention is constituted as mentioned above, the deformation resistance at the time of bolt shaping can be low, therefore can maintain the tool life for bolt shaping good, and can aim at reduction of the production cost at the time of bolt processing. Moreover, since the variation in the tensile strength of rolled stock was reduced, the reinforcement of a bolt itself is stabilized and a predetermined value came to be shown.

[Translation done.]

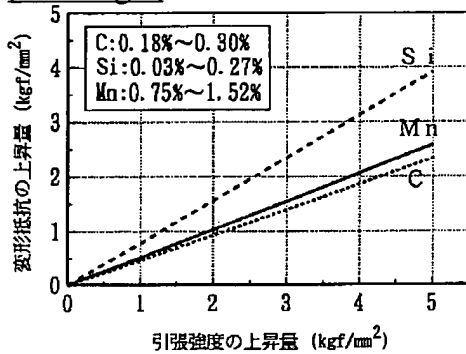
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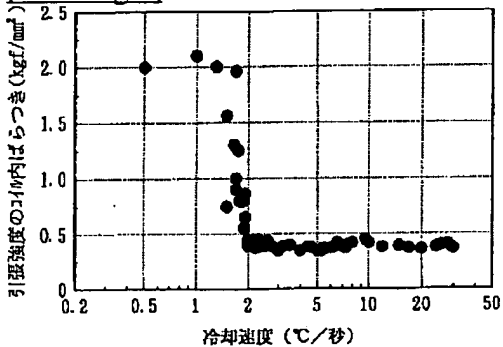
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

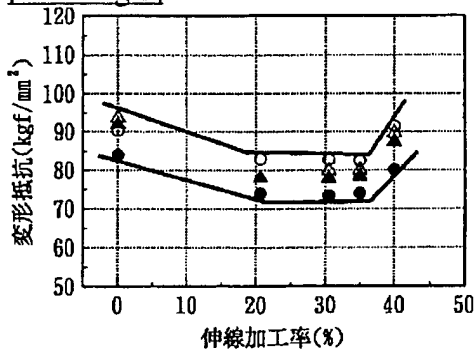
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]